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AUTHOR Reneau, Fred; And Others

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ABSTRACT

This booklet presents informative materials on fertilizer use and water quality, specifically in regard to environmental pollution and protection in Illinois. The five chapters cover these topics: Fertilizer and Water Quality, Fertilizer Use, Fertilizers and the Environment, Safety Practices, and Fertilizer Management Practices. Key questions are found at the end of each chapter. The answer sheet is located following chapter 5. A glossary of terms is provided. The script to a slide/filmstrip is attached. (YLB)

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FERTILIZER USE AND WATER QUALITY

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Fertilizer Use and Water Quality

Prepared by

Fred Reneau
Janise Richards
Tom Stitt
Jim Legacy
Department of Agricultural Education and Mechanization
Southern Illinois University - Carbondale

January 1982

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CONSULTANTS

Lloyd Burling	Illinois Fertilizer and Chemical Association
Reggie Cook	Tri-County Fertilizer, Inc.
E. J. Dunphy	Lake Land College
Gerald Forbeck	Twin County Service Company
Sam Robb	Pinckneyville High School
Ed Varsa	Southern Illinois University

ADVISORS

Marie Lauricella	Illinois Department of Energy and Natural Resources
A. G. Taylor	Illinois Environmental Protection Agency

STAFF

Brian Crawford	Southern Illinois University
Vicki Fenno	Southern Illinois University
Sharon Flanagan	Southern Illinois University
Malina Heil	Southern Illinois University
Pat Kambesis	Southern Illinois University

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CHAPTER 1

Fertilizer and Water Quality

Fertilizers have been used to improve crop yields for centuries. The benefits of fertilizer makes it an important part of farming practices. Water quality, too, is important. Without fresh and clear water, human, plant, animal, and aquatic life could not survive.

With the help of fertilizers, American farmers produce more food and fiber than is needed by the United States. This surplus has helped the United States become one of the leading agricultural exporters in the world. A projection from the total yields of corn, soybeans, and wheat, in 1985, for Illinois alone is one million, six hundred and eighteen thousand bushels.

Although fertilizers benefit agricultural production, adverse environmental effects may be caused by their misuse and/or overuse. Since 1945, fertilizer consumption has steadily increased from four thousand tons of nitrogen and thirty-four thousand tons of phosphates, to nine hundred and seventy-seven thousand tons of nitrogen and eighty-seven thousand tons of phosphates in 1977 in Illinois.

The increase of fertilizer use in Illinois has caused concern about the potential movement of nitrogen and phosphorus into water sources. The Mississippi and Ohio river systems form over half of the borders of Illinois. These, plus Lake Michigan, the Illinois River, and many other lakes and streams make up Illinois' surface water resources. Pollution of these water sources by fertilizers must be minimized. Sound fertilizer management practices are essential for maintaining water quality.

To control environmental pollution, the United States Congress passed the Federal Water Pollution Control Act Amendment of 1972. This Act set up a process to identify non-point sources of pollution and procedures and methods to control such sources. The Law (Public-Law 92-500 and its amendments) gave the Federal Environmental Protection Agency (U.S. EPA) an order to restore and maintain the quality of the nation's water resources.

PL 92-500

Under the Safe Drinking Water Act (PL 93-523), the U.S. EPA is "directed to establish minimum national drinking water standards which set limits on the amount of various pollutants in

drinking water supplies. States must adopt standards at least as strict as the natural standards."

To carry out the provisions of these federal acts at the state level, the Illinois Environmental Protection Agency (IEPA) was established in 1970 with the passage of the Environmental Protection Act. The Act specifically states, no person shall:

1. Discharge any contaminants into the environment so as to cause or tend to cause water pollution in Illinois;

2. Construct, install, or operate any equipment, facility, or aircraft capable of causing or contributing to water pollution;

3. Deposit any contaminants upon the land in such place and manner so as to create a water pollution hazard;

4. Discharge any contaminant into Illinois water resources; this includes sewage works, well, lakes, and all other water sources.

KEY QUESTIONS

CHAPTER 1

1. The benefits of _____ make it an important part of farming practices.
2. Fertilizers can have adverse effects on the _____.
3. Sound fertilizer management practices are essential to maintaining _____ quality.
4. The Law (PL 92-500 and its amendments) gave the _____ an order to restore and maintain the quality of the nation's water resources.

Answers are listed in the back of the booklet under Chapter 1.

CHAPTER 2

Fertilizer Use

All plants grow and reproduce in response to an interaction of factors in the environment. For maximum yields, plants must have:

1. Optimum air and soil temperatures.
2. Available soil water and soil air.
3. Ample light.
4. The essential elements of nutrition available when needed.

Fertilizers are used to supply essential elements to the plant.

Macronutrients and Micronutrients

Many years of research have identified the essential elements needed by plants for growth and reproduction. Although some species require specific nutrients, most plants require sixteen basic elements, with the help of light and heat, to manufacture food. The foods produced by plants are the basis of all animal and human life. Fertilizers make it possible for farmers to provide all sixteen elements in available and balanced proportions. The sixteen elements are divided into two broad categories, macronutients and micronutrients.

Essential Elements

Macronutrients	Micronutrients
Hydrogen (H)	Zinc (Zn)
Oxygen (O)	Iron (Fe)
Carbon (C)	Copper (Cu)
Nitrogen (N)	Manganese (Mn)
Phosphorus (P)	Boron (B)
Potassium (K)	Molybdenum (Mo)
Calcium (Ca)	Chlorine (Cl)
Magnesium (Mg)	
Sulfur (S)	

Macronutrients. Nine of the sixteen basic elements are called macronutrients. Hydrogen (H), Oxygen (O), and Carbon (C), are obtained from air and water. Because these elements are easily available to the plants, they are not as important in fertilizer application consideration.

Nitrogen (N), Phosphorus (P), and Potassium (K), are considered primary nutrients. The primary nutrients are available to plants from soils and fertilizers in the common chemical forms:

Nitrogen	NH_4^+ and NO_3^-
Phosphorus	$H_2PO_4^-$ and HPO_4^{2-}
Potassium	K^+

The primary nutrients are needed by the plants in substantial amounts. Since these three nutrients are used by the plants in large quantities, frequently soils are depleted of them after a few years of cultivation.

Magnesium (Mg), Calcium (Ca), and Sulfur (S), are known as secondary elements. Plants require these elements for normal

growth, but are not usually added to fertilizers in large quantities. Secondary nutrients are available to plants from soils and fertilizers in the common chemical form:

Calcium	(Ca^{2+})
Magnesium	(Mg^{2+})
Sulfur	(SO_4^{2-})

The requirements of secondary nutrients depend on the plant species, soil conditions, and environment. Research has indicated that deficiencies of magnesium and sulfur are becoming more common.

Micronutrients. Seven of the sixteen basic nutrients are called micronutrients. The term micronutrients often is misinterpreted to mean minor nutrients. The term micronutrients means the nutrients are needed in smaller amounts. Even though they are needed in smaller amounts, deficiencies in them can lead to stunted plant growth or limited yields. Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mn), Boron (B), Molybdenum (Mo), and Chlorine (Cl), are classified as micronutrients.

Micronutrients are available to plants from soils and fertilizers in the common chemical forms:

Zinc	(Zn^{2+})
Iron	(Fe^{2+} and Fe^{3+})
Copper	(Cu^{2+})
Manganese	(Mn^{2+})
Boron	($H_2BO_3^-$)
Molybdenum	(MoO_4^{2})
Chlorine	(Cl^-)

Since micronutrients are needed in less quantity, applications can be either soil or foliar. The possibility of coating the seed with some of the elements is also feasible.

Soil Fertility

To determine whether or not fertilizer must be used or which ones to apply, farmers must know the fertility of the land. Soil fertility is the quality that allows the soil to provide the essential elements in the proper amounts for growth of plants when environmental factors are favorable. By taking soil samples every four years in the late summer or fall, farmers can decide on application rates. A common mistake is to take too few samples to adequately represent the field. A minimum of five soil samples on every three or four acres should be taken and combined to make one composite sample for a homogeneous area. Illinois has about 65 commercial soil-testing services. County extension advisors have information on the soil-testing services in their area.

Nitrogen Fertilizers

About 78% of the earth's atmosphere is composed of nitrogen in the chemical form N_2. Unfortunately, this form of nitrogen can not be utilized directly by most plants. Nitrogen is also a component of soil organic matter. This organic form is also unavailable for plant use. But when bacteria decompose organic compounds into inorganic forms, the nitrogen becomes available to the plant. The organic forms of nitrogen take a longer amount of time to break

down and become available to the plants than application of nitrogen in its inorganic form. This is one reason why nitrogen fertilizer has helped boost agricultural production in a few decades.

Commercial nitrogen fertilizers come in different forms. Anhydrous ammonia (NH_3), nitrogen solutions, Urea [$CO(NH_2)_2$], ammonium nitrate (NH_4NO_3), ammonium sulfate [$(NH_4)_2SO_4$] and slow-release fertilizers are some common types. These fertilizers are available in gaseous, liquid, or solid form. Each of these nitrogen sources are beneficial to crop production but can be harmful to the environment if carried away by wind, rain, or soil erosion into water sources.

Phosphorus Fertilizers

Phosphorus is found in the earth's soils in varying quantities. Soil phosphorus occurs in three main categories: inorganic phosphorus compounds, organic phosphorus compounds, and soil solution phosphorus.

Sources of organic phosphorus which have long been used are crop residue and animal manure. The concentrations of phosphorus are generally low in these sources. But very heavy rates of application over an extended period of time can increase available phosphorus to high levels which may injure plants.

For over a century, rock phosphate has been used to raise phosphorus level in the soil. The use of rock phosphate as a phosphorus source is limited to soil with low pH (acid soils). The insoluble phosphate compounds in rock phosphate will dissolve under

acid conditions. Rock phosphate is no longer used as a source of phosphorus in Illinois. It is now used to produce other phosphorus fertilizers.

Superphosphate was developed through an industrial process which combines sulfuric acid with rock phosphate. The phosphorus concentration ranges from 8 to 8.8% phosphorus. By using superphosphate, the farmer can add sulfur, in addition to phosphorus during application.

Triple superphosphate has a higher phosphorus concentration than superphosphate (17 to 21% phosphorus). To produce triple superphosphate, rock phosphate is combined with phosphoric acid. Triple superphosphate is often used in the manufacture of dry bulk blends or for direct application. It has a high water solubility. New procedures and developments have created tripolyphosphoric acid and pyrophosphoric acid which have even greater concentrations of phosphorus.

Additional formulations can also be made with ammonium, urea-ammonium, and potassium. With these, the farmer can add different needed elements at one time.

Potassium Fertilizers

Potassium is the seventh most abundant element in the crust of the earth. Usually, it is found combined with other elements in a mineral form. This mineral form is called ore. Potassium ore is excavated by both strip and underground mining. The ore is crushed into a fine powder and separated by a flotation process.

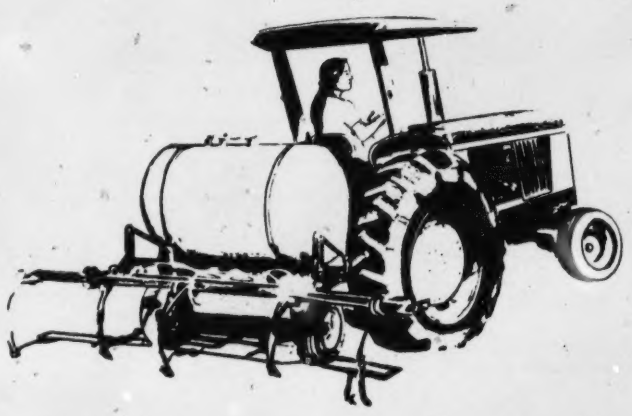
Even though potassium is abundant in the earth's crust, most of it is in unavailable forms in the soil for plant use. So, farmers apply available forms of potassium to their fields. Potassium chloride (KCl) or muriate of potash is a widely used potassium fertilizer. Potassium nitrate (KNO_3), potassium hydroxide (KOH), or potassium phosphates (K_3PO_4, K_2HPO_4, KPO_3) are other forms of potassium fertilizers used.

Analysis of Chemical Fertilizers

N-P-K

Chemical fertilizers, which contain more than one macronutrient, are called mixed or complete fertilizers. On the bag, tank, or tag, the analysis is given for the nitrogen (N), the phosphorus (P or P_2O_5), and the potassium (K or K_2O) in that order. Thus, an 8-16-16 fertilizer contains eight percent total nitrogen, 16 percent available P_2O_5, and 16 percent water soluble K_2O.

Summary



Fertilizers come in many different forms and analyses. Each has its own place in solving elemental deficiencies in soil. Macronutrients are elements needed by plants in large amounts for growth and development. Equally as important, but needed in smaller amounts, are micronutrients. To determine

the need for addition of nutrients and micronutrients, a soil sample should be taken from different areas of a field, combined, and tested at a reputable soil testing service.

When fertilizers leach or are carried from fields by erosion and runoff into water sources, there is potential for pollution. Potassium usually is not connected with water pollution. Phosphorus, in its phosphate form, is highly adsorbed to clay particles and can move into water sources by erosion. In its inorganic form, phosphorus, even in very small amounts, can increase biological activity in streams, lakes, ponds, and other water sources. Nitrogen, which chemically breaks down into nitrates and nitrites, is a major contributor of fertilizer related pollution in Illinois water sources.

KEY QUESTIONS

CHAPTER 2

1. Fertilizers are used to supply the plant the essential _____ to the soil.
2. Most plants require _____ basic elements with the help of light and heat, to manufacture food.
3. Nitrogen (N), Phosphorus (P), and Potassium (K), are considered _____ nutrients.
4. The term micronutrients means the nutrients are needed by plants in _____ amounts.
5. Soil _____ is the quality that allows the soil to provide the proper nutrients in the proper amounts for growth of plants.
6. By taking soil samples every four years in the late summer or fall, farmers can decide on _____ rates.
7. Each of these nitrogen sources are beneficial to crop production but can be harmful to the environment if carried away by wind, rain, or soil erosion into _____ sources.
8. Potassium usually is not connected with _____ pollution.
9. Phosphorus can increase _____ activity in streams, lakes, ponds, and other water sources.

Answers are listed in the back of the booklet under Chapter 2.

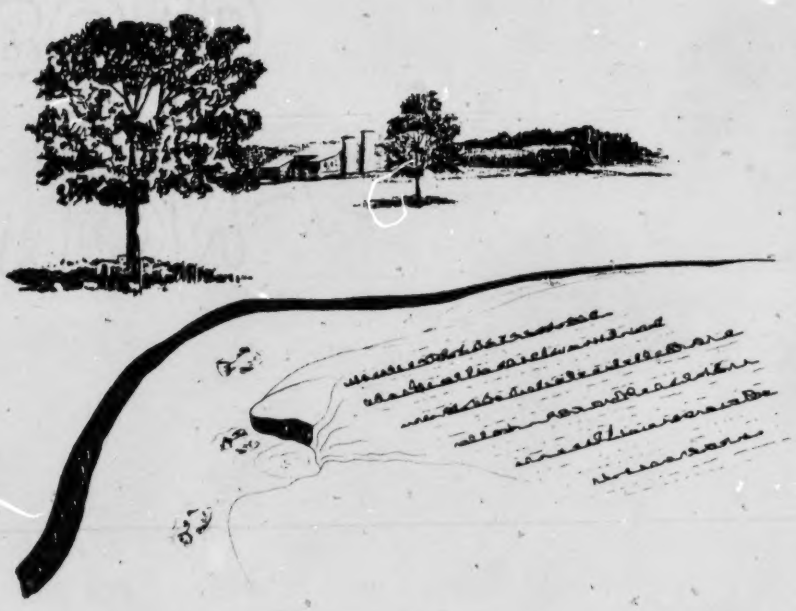
CHAPTER 3

Fertilizers and the Environment

Illinois soils are considered some of the most productive soils in the United States. With the help of fertilizers, Illinois is one of the leading states in agricultural production. Properly applied fertilizers aid farmers and crop production by increasing yields and improving food quality. The latest data indicates that fertilizer sales in Illinois increased fifty-seven percent for nitrogen, phosphorus, eleven percent, and potassium, thirty-seven percent in a five-year span. This boost of fertilizer use on Illinois soils may have a potential for serious pollution of Illinois water resources.

Fertilizers - An Environmental Pollutant

Fertilizers become a hazard to the environment when they move off of cropland into water sources. Dissolved soluble chemicals can leach from the soil. Run-off water can carry these dissolved nutrients into water sources. Nutrients



adsorbed to soil particles can enter water sources by soil erosion. When fertilizers enter water systems an unbalance in the natural levels of nutrients results. This water may become toxic to humans, animals, fish, and plant life. Knowing how fertilizers contaminate water and how to use fertilizers safely, may help applicators minimize the potential hazards.

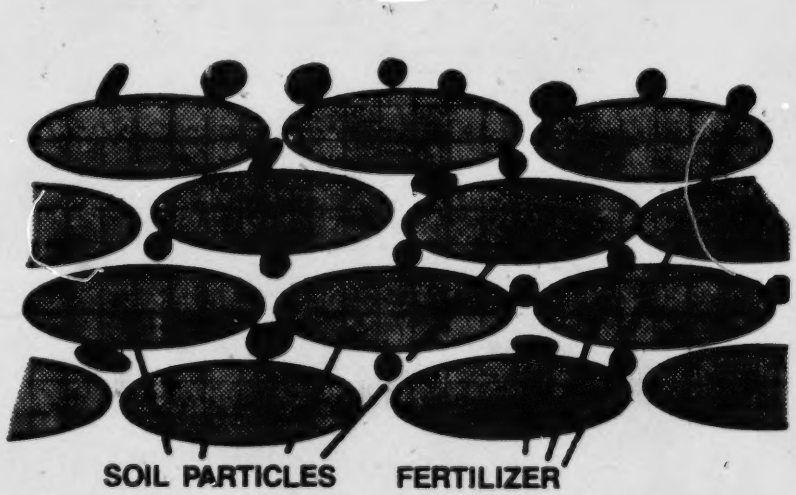
Leaching. One way nutrients can enter water sources is through leaching. Nutrient leaching is the removal of dissolved minerals from soils by water that is percolating through the soil. Leaching can result in nutrients being carried away into water sources causing water pollution. Understanding the leaching process and avoiding application of fertilizers when and where leaching may take place can help reduce this hazard.

The loss of nutrients through leaching is determined by climatic factors and soil-nutrient interactions. In areas with high humidity, frequent soil saturation by rain or irrigation creates water percolation of the soil, and the potential for leaching is very strong.

Soil properties have a definite effect on nutrient leaching. Finer textured soils usually have a lower percolation rate than do coarse textured, sandy soils. The soil's cation exchange capacity also affects the leaching of nutrients. Soils with a high cation exchange capacity tend to hold nutrients and prevent leaching. But, if some chemical fertilizers are added in large amounts, these soils, which are often naturally high in nutrients, can create reservoirs of nutrients which are subject to leaching.

To evaluate the amount of leaching of nutrients from croplands, three methods mainly used are lysimeter studies, monitoring tile drains, and taking core samples. Drainage lysimeters are columns of soil in a field surrounded by impermeable cylinders. Water which drains out of them is collected and tested. Tile drains are pipes in short lengths which are usually laid beneath the soil with open joints to collect and carry excess water from a field. A sample of a much larger area can be provided by the drains. Core samples of soil are usually made by drilling to a depth of four feet or more with a hollow bit. A profile of the soil is then examined to determine the movements of nutrients.

Soil erosion. Many fertilizers have qualities that cause them to stick to small soil particles. This attraction is known as adsorption. Adsorption is necessary for fertilizers to do their jobs effectively. It also helps fertilizers avoid polluting surface water. Adsorption complicates fertilizer use when soil erosion occurs and the adsorbed nutrients move out of the field with the eroded soil particles. Damage to streams, rivers, lakes, and other water systems can result when the adsorbed nutrients are dissolved into the water. The problem is especially critical because the finer



soil particles, the clay and humus colloids which have a higher capacity to adsorb nutrients, are the most easily eroded. Soil conservation practices will reduce the hazard of adsorbed nutrients contaminating water systems.

Runoff water. Runoff refers to loss of water by surface flow to stream channels. Runoff occurs when the rate of water application to the soil exceeds the rate of water infiltration into the soil. The highest potential for water pollution exists when the solubility of a fertilizer is high, such as nitrates, or when the soil characteristics are such that fertilizers are not easily adsorbed. Soil properties, such as pH, cation exchange capacity, moisture content, mineral clay content, and organic matter combine to control the adsorption rate. Surface applied fertilizers can dissolve in water. High concentrations of nutrients can be washed off of soils into water systems when there is a heavy rain soon after surface fertilizer applications. To prevent water pollution from runoff, surface applications of fertilizers should not be made when heavy rains are forecasted.

The Nitrogen Problem

Nitrogen fertilizer use has increased in Illinois. Harvested crops remove more nitrogen than any other nutrient. Erosion removes the surface soil which is the richest in nitrogen. Other losses of nitrogen occur through denitrification and leaching. The increase in the use of nitrogen fertilizer to replace these lost nutrients can lead to an overabundance of nitrogen in the environment through further leaching and erosion if not controlled.

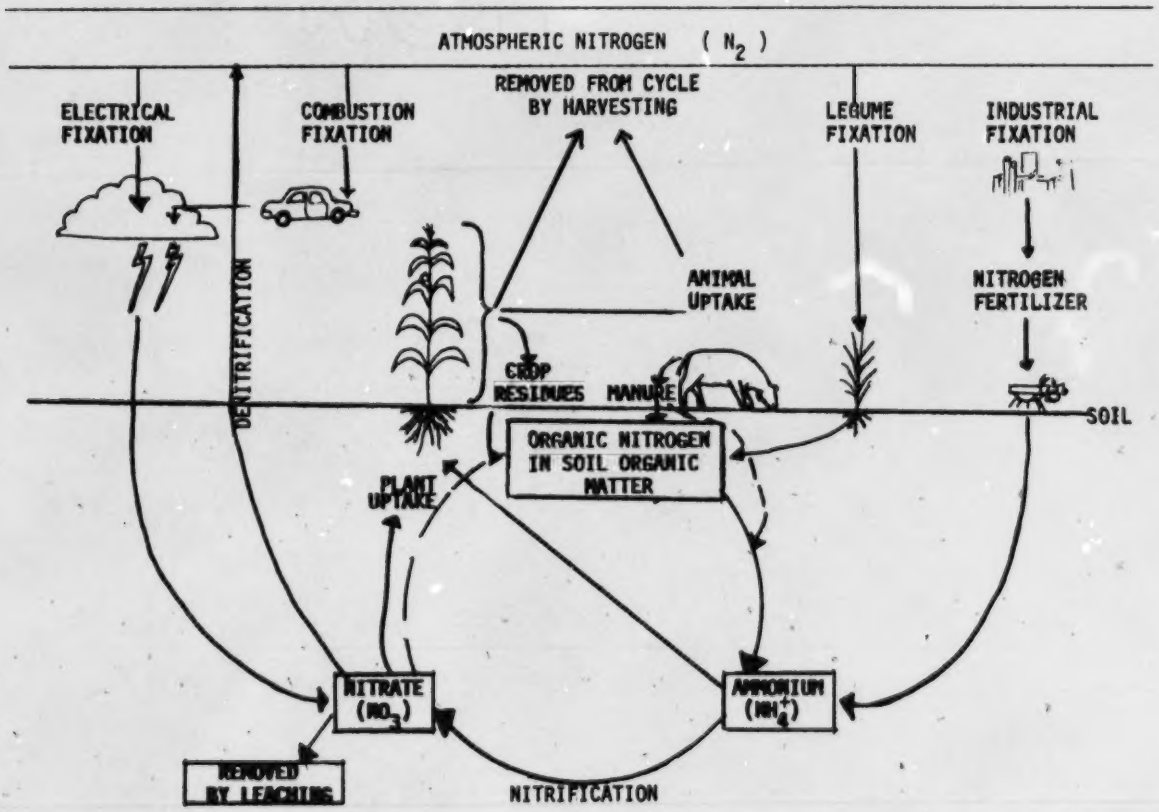
When fertilizers are added to the soil, the nitrogen is primarily in the ammonium form (NH_4^+) which is available for plant use. If the ammonium is not taken in by plants, bacteria begin to change ammonium form to a nitrate form (NO_3^-) in a process called nitrification. Nitrate forms of nitrogen may leach quickly because nitrates are not adsorbed by clay particles, and they are very soluble in water.

An intermediate step in the nitrification process of ammonium by bacteria, is the nitrite form (NO_2^-) of nitrogen. Nitrites are five to ten times more toxic than the nitrate form. Nitrogen is only in its nitrite form in the soil for a very short time. Nitrites and nitrates interact with components in the blood to interfere with oxygen transport in the body. This may be fatal to animals and humans if not properly treated. Young children are susceptible to this disease called methemoglobinemia. This is the condition which causes "blue baby syndrome".

The U. S. Public Health Service established the Drinking Water Standards of 1962 to set a limit for nitrates in water systems for human consumption. A maximum limit was fixed at ten milligrams nitrogen per liter of water or 45 ppm nitrate. There has been some concern that even lower levels of nitrates may interfere with normal metabolism.

Fish, animal, and plant life are also sensitive to nitrogen forms in the water systems. As little as one to two ppm of dissolved ammonia can be fatal to some species of fish.

The difficulty of pinpointing the source of nitrates in water sources comes partly from the complexity of the nitrogen cycle. Once nitrogen has started through the cycle, nitrates from fertilizers are difficult to recognize. Measurement of nitrates from fertilizers is complicated by input from other sources such as industrial pollution from factories, sewage disposal plants and automobiles. Thus, the specific source cannot always be determined.



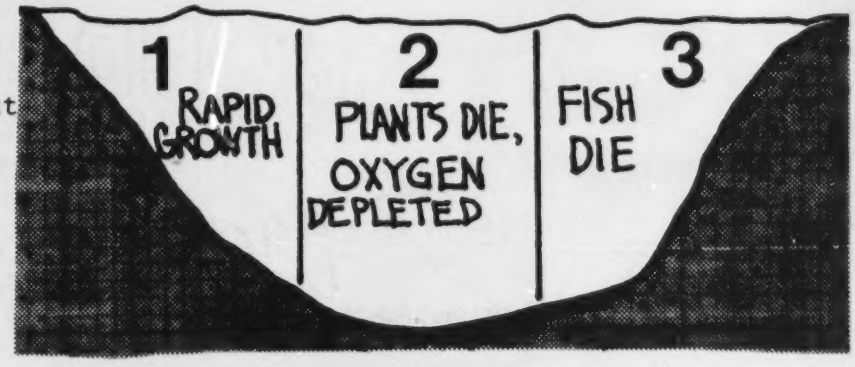
Research has shown that fifty percent or less of the nitrogen from fertilizer applications are used by crops. The rest of the nitrogen keeps moving through the cycle pathways of: absorption by bacteria, denitrification, fixation by certain clay minerals, and leaching. Fertilizer users must be aware of possible movement of nitrogen out of this cycle into nearby streams, rivers, ponds, and lakes. It is the responsibility of nitrogen fertilizer users to effectively minimize the potential of nitrogen pollution in Illinois water resources.

The Phosphorus Problem

Since the early 1960's, the amount of phosphorus fertilizer used by Illinois farmers has steadily increased. Many surface soils have reached a point where the phosphorus content is unnecessarily high for the best economic yields. Because phosphorus is immobile in soil, it can build up in the soil. Once the soil has reached a specified nutrient level, the amount of phosphate fertilizer needed is equal to the amount removed by the harvested crop. This practice is economical and decreases the chance of phosphate pollution of water sources.

The water solubility of most phosphorus compounds is low. Also, these compounds are highly attracted to clay particles. These two characteristics tend to keep phosphates from leaching from the soil into water systems. Soil erosion and the clay particles in runoff water move phosphates from fields into water systems.

When phosphates enter water systems, the normal nutrient levels are exceeded, increasing the growth of plants. This enrichment of water by nutrients and the resulting vigorous growth of plants is called eutrophication. In 1978, a study by the Illinois Enviromental Protection Agency found three hundred and fifty-three Illinois lakes in an eutrophic state.

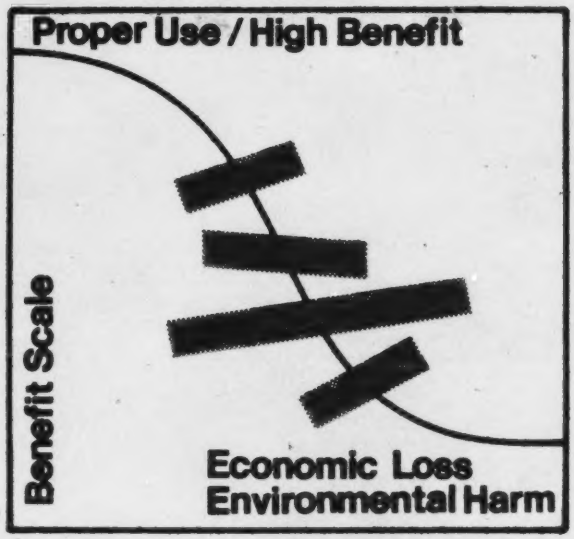


The problem with eutrophication begins when the concentrations of nitrogen exceed about 0.3 milligrams/liter, and the concentration of phosphorus surpasses about 0.015 milligrams/liter. The concentrations of phosphorus are most important in bringing about accelerated eutrophication. The excess nutrients cause rapid growth of algae and aquatic plants. When a large amount of plant materials die, the biological activity involved in its decay uses up the dissolved oxygen supply from the water. Without the dissolved oxygen in the water, fish cannot live. This process may take a long period of time to reach the final stage in which there is no dissolved oxygen for aquatic life. Many outside factors, such as water movement, plant species, and environmental conditions can speed up or slow down the process.

The sources of phosphorus compounds, like the nitrogen compounds, are difficult to pinpoint. Sources, such as municipal and industrial wastewaters, aquatic birds, rain, and urban storm water runoff, can add to the phosphorus levels of water systems. But the increasing use of phosphorus fertilizers in agriculture may be a major source of phosphorus compounds in water systems.

Summary

The benefits from the use of fertilizers in agriculture cannot be overstated. With the help of fertilizers, American farmers aid in the feeding of a hungry world. The overuse of fertilizers can lead to economic and environmental problems. Economic loss arises when unneeded nutrients are applied to the soil or when nutrients are moved from the field by leaching, soil erosion, or runoff. Environmental problems, such as toxic levels of nitrates and eutrophication, can occur when nitrogen and phosphorus fertilizers enter lakes, ponds, rivers, and streams.



KEY QUESTIONS

CHAPTER 3

1. With the help of fertilizers, Illinois is one of the leading states in the production of agricultural _____.
2. Leaching can result in nutrients being carried away into _____ resources.
3. The attraction causing fertilizers to stick to small soil particles is known as _____.
4. Soil _____ practices will reduce the hazard of adsorbed nutrients contaminating water systems.
5. Runoff occurs when the rate of water application to the _____ exceeds the rate of water infiltration.
6. Harvested crops remove more _____ than any other nutrient.
7. The increase in the use of nitrogen fertilizer to replace lost nitrogen can lead to an _____ of nitrogen in the environment through further leaching and erosion if not controlled.
8. Nitrate form of nitrogen may leach quickly because nitrates are not absorbed by clay particles, and they are very _____ in water.
9. Nitrites and nitrates interact with components in the blood to interfere with _____ transport in the body.
10. The U. S. Public Health Service established the Drinking Water Standards of 1962 to set a _____ for nitrates in water systems for human consumption.

11. The difficulty in pinpointing the source of nitrates in water sources comes partly from the complexity of the _____ cycle.
12. Many surface soils have reached a point where the phosphorus content is unnecessarily high for the best _____ yields.
13. The enrichment of water by nutrients and the resulting vigorous growth of plants is called _____.
14. Without the _____ oxygen in the water, fish cannot live.
15. The overuse of fertilizers can lead to economic and environmental _____.

Answers are listed in the back of the booklet under Chapter 3.

CHAPTER 4

Safety Practices

Safe use of fertilizers is essential to the health of the applicator and the environment. Fertilizers are not usually thought of as dangerous chemicals. Therefore, fertilizers are frequently not handled cautiously. When loading or unloading bulk fertilizers, protective gloves and goggles should be worn to prevent dusts, vapors, or liquid from entering eyes and small cuts in the hands. Responsible use and storage of fertilizers is an effective method to reduce potential harm to applicators and the environment.

Storage

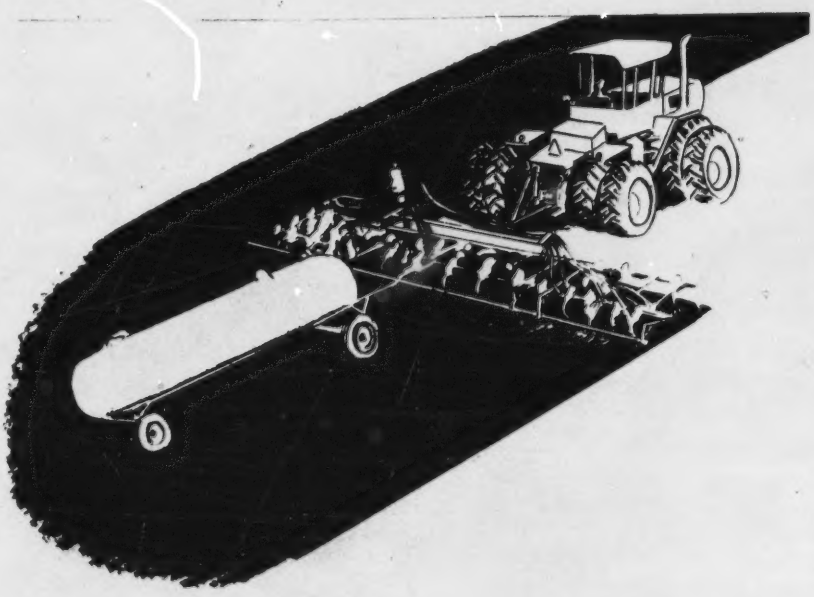
Dry and liquid fertilizers should be stored where there is no exposure to the weather. A tight storage shed or well-sealed facilities should be located downhill and downwind from residences, play areas, livestock areas, and water sources. Avoid storing fertilizers where accidental loss of nutrients would contaminate

surface water or wells. Responsible storage of fertilizers will help reduce the chance of economic loss of nutrients.

Safe Use of Anhydrous Ammonia

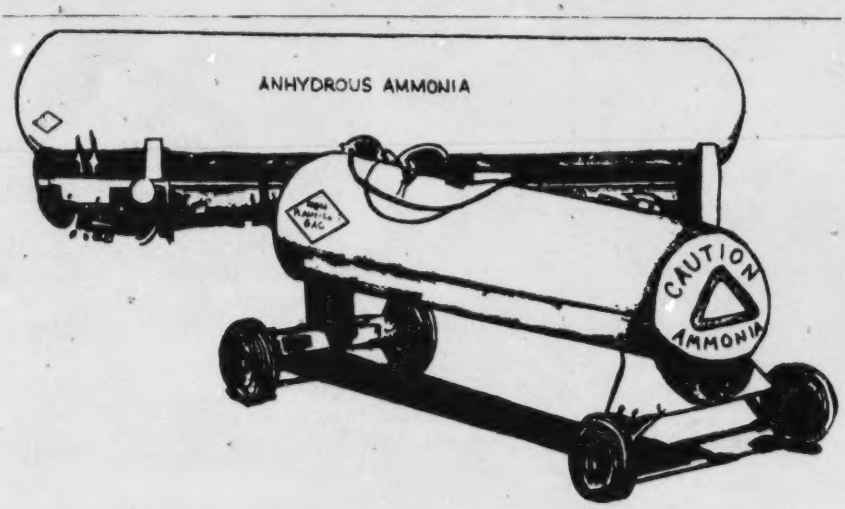
Anhydrous ammonia (NH_3) is the most common form of nitrogen fertilizer used by Illinois farmers. It may be dangerous unless precautions are taken. The applicator should know the product, its characteristics, and behavior.

Anhydrous ammonia is a gas under atmospheric temperature and pressure. It is colorless, lighter than air, and has a pungent, irritating odor. Anhydrous ammonia can be compressed to a liquid in which form it is usually handled.



The boiling point of anhydrous ammonia is -28 degrees Farenheit. This characteristic causes anhydrous ammonia to immediately freeze skin tissue on contact. Ammonia is one of the most water soluble of all gases. Ammonia is strongly attracted to moisture resulting in possible injury to the eyes, skin, mucous membranes and respiratory tract. Flushing with water is the most effective treatment of areas that have been in contact with anhydrous ammonia.

The applicator should only use equipment suitable for anhydrous ammonia service, and make sure it is properly installed. Liquid anhydrous ammonia expands as temperature rises. This expansion must be considered in the design and operation of equipment. If ammonia is dissolved in water, it will react with copper, zinc, and many alloys, especially brass. Stainless steel is best for fittings.



The applicator should establish a sound program for inspection, repair, and maintenance of equipment. Many applicators use equipment from their ammonia supplier. It is the supplier's responsibility to see that tanks and equipment meet federal and state standards. But it would be of benefit to both the supplier and applicator if the equipment was checked daily. A routine check should be made of:

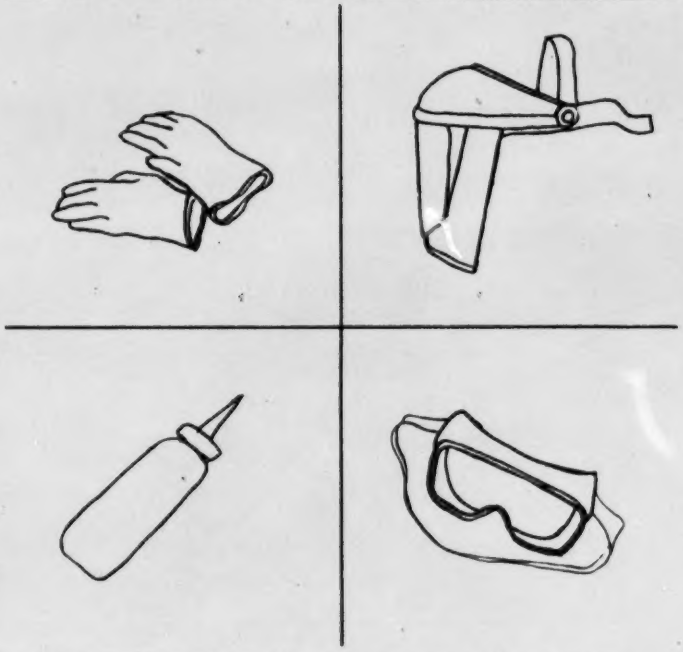
1. ammonia tank - free of leaks, solid tank supports, and paint in good condition,
2. valves, fittings, and accessories - free of leaks, rust, and dirt, operating properly,
3. piping - free of leaks, rust, and damage,
4. hoses - free of damage or deterioration, securely clamped, not dragging,

5. transfer equipment - belt tension okay, belts in safe condition, pump coupling in good condition, guards in place,

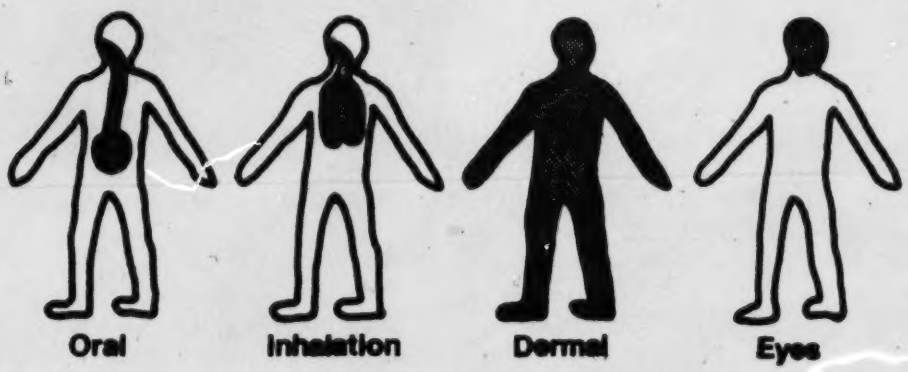
6. transport vehicles, nurse tanks, and applicator - tanks securely attached, wheels in proper alignment, tires in good condition and properly inflated, trailer tongues, hitches and safety chains in sound condition.

Make sure all ammonia is out of the ammonia system before dismantling or repairing it. Frosting and sweating can indicate trapped liquid ammonia which is vaporizing. Leaks in equipment should be repaired immediately. To detect leaks, usually the smell of ammonia fumes is enough, but moistened strips of red litmus paper will turn blue in the presence of ammonia.

The applicator should provide and maintain standard protective equipment. Rubber gloves and tight fitting goggles must be worn when working with anhydrous ammonia. Boots and clothing (constructed of closely woven cotton) are recommended. Gas masks with ammonia-type canisters should be worn. A fresh water supply of five gallons or more must be on both the nurse tank and tractor. A small pocket squeeze bottle full of water should be carried at all times for immediate access in case of eye injury.



Accidents involving anhydrous ammonia can happen from equipment failure and disregard of proper operating instructions. Water is the best emergency treatment to stop anhydrous ammonia injury.



Oral injury. In unusual circumstances, if liquid anhydrous ammonia is swallowed, call a physician immediately. A conscious and able person should drink large amounts of water to dilute the chemical.

Inhalation injury. Exposed persons should be moved at once to an uncontaminated area. If the exposure has been to minor concentrations for a limited time, usually no treatment is required. A severe exposure requires oxygen to be administered by authorized persons and a physician called.

Dermal injury. Speed is extremely important in removing ammonia from the skin and mucous membranes. Anhydrous ammonia is very caustic, and as long as it is in contact with skin and mucous membranes, tissues will be destroyed. Water should be poured over the injured area immediately. The person should then be moved to

an uncontaminated area. Clothing contaminated with anhydrous ammonia should be removed under pouring water if frozen to the skin. Do not use salves or ointments on anhydrous ammonia burns for 24 hours after the burn. It will cause deeper burns.

Eye injury. Anhydrous ammonia can cause blindness if treatment is delayed. A small pocket plastic squeeze bottle is invaluable to give eyes immediate attention. A larger supply of water should be used to wash eyes properly. Eyes must be forced open and held to insure contact of water with all tissues for at least 15 minutes. Anhydrous ammonia will cause eyes to close involuntarily. If irritation still exists, eyes should be doused for a second 15 minute period. A physician should be contacted.

Summary

It is a proven fact anhydrous ammonia can be a safe fertilizer when it is handled with proper equipment, proper care, and precaution. All persons who use anhydrous ammonia are responsible for using it in a safe manner for themselves and for others.

The safe use of fertilizers, especially anhydrous ammonia, is essential to the health of the applicator. The applicator should use recommended equipment when working with fertilizers. Accidents occur most often when the equipment is faulty or the applicator fails to follow recommended operational procedures.

KEY QUESTIONS

CHAPTER 4

1. Each person who uses _____ should do so in a safe and sound management manner to reduce the potential contamination of Illinois water resources.
2. Fertilizers are not usually thought of as _____ chemicals.
3. Responsible storage of fertilizers will help reduce the possibility of accidental _____ of water resources.
4. _____ ammonia is a gas under atmospheric temperature and pressure.
5. Ammonia is one of the most _____ soluble of all gases.
6. The applicator should only use equipment _____ for anhydrous ammonia service.
7. The _____ should establish a sound program for inspection, repair, and maintenance of equipment.
8. The applicator should provide and maintain standard _____ equipment.
9. A fresh _____ supply of five gallons or more must be on both the nurse and tractor.
10. _____ is the best emergency treatment to stop anhydrous ammonia injury.
11. If liquid anhydrous ammonia is swallowed, a conscious and able person should_____ large amounts of water to dilute the chemical.

12. If anhydrous ammonia has been _____, exposed persons should be moved at once to an uncontaminated area.
13. Anhydrous ammonia is very caustic, and as long as it is in contact with skin and mucous membranes, tissues will be _____ .
14. Water should be _____ over the injured area immediately.
15. Anhydrous ammonia can cause blindness is treatment is _____ .

Answers are listed in the back of the booklet under Chapter 4.

CHAPTER 5

Fertilizer Management Practices

Connection between the use of fertilizers and concentrations of nutrients in water systems has been recognized, although the specific sources of these pollutants are not easily identified. Fertilizers can be a contributing factor to the decline of Illinois water quality. Each person who uses fertilizers should do so in a safe and sound manner to reduce potential contamination of Illinois water resources.

Soil Management Practices

Most nutrient movement from the field is from leaching, erosion, and runoff. To control this movement of nutrients, sound soil management practices must be utilized. Soil conservation practices have been stressed for more than forty years. Use of soil conservation practices, such as minimum tillage, no-tillage (zero-tillage), covercropping, contouring, and terraces, have proven to be helpful in reducing movement of nutrients.

Tillage. The greater the amount of residue left on a field, the smaller the amount of erosion. Leaving the crop residues on a field can decrease runoff up to fifty percent. No-till or zero tillage was found to be effective in both soil erosion and runoff control.

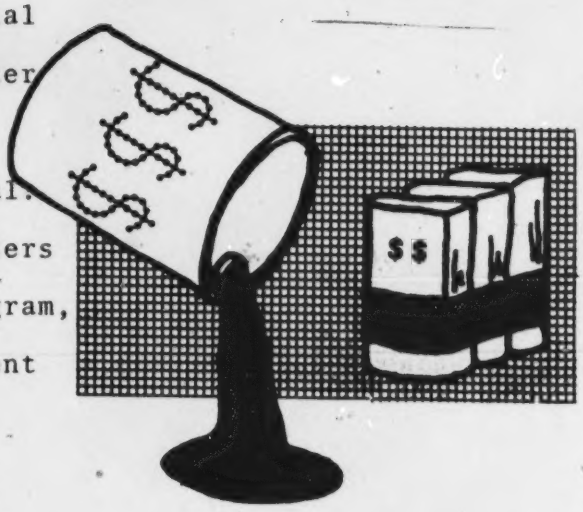
Covercropping. The practice of sowing a cover crop during the winter months reduces runoff and soil erosion. Rye grass, clover and various legumes used as cover crops help hold the soil to the field. Plus, they give an added benefit of green manure in the spring, adding to the soil organic matter.

Contouring. Nutrient loss will be reduced by breaking up the long slopes where soil erosion is common. Fertilizers should not be applied on the surface of barren soil with a slope of more than five percent.

Fertilizer Management Practices

Nutrient loss and pollution of water resources can be controlled by the use of sound fertilizer management practices. Management practices which improve plant growth, promote efficient uptake of applied nutrients by growing crops, and reduce erosion

and runoff, will minimize the potential adverse effects of fertilizers on water quality. The most efficient use of fertilizer is also the most economical. Eliminating excessive use of fertilizers and using a sound soil fertility program, will contribute to both the environment and profits.



Soil Tests. The most important guide to the proper use of fertilizer is a regular soil test. A study in Illinois showed that forty percent of the fields sampled were above suggested levels for phosphorus. Twenty percent of these fields has potassium levels above the suggested levels. Soil tests will indicate nutrients needed for the profitable use of fertilizers. When checking a soil sample, have tests made for soil pH (soil acidity), bray P_1 (available phosphorus), and K (potassium). Tests on soil organic matter content and cation exchange capacity may also be beneficial. Information on the history of the field in which the soil sample was taken and a geographic description will help in making fertility recommendations.

Build-up Program. A build-up program establishes a procedure to increase soil fertility to desired nutrient levels. This program usually consists of a soil test, establishment of amount of fertilizer needed, decisions on forms of fertilizer to use and what

analysis would be best suited, an estimate of cost, and a determination of where and when to apply the fertilizers.

Once the deficiencies have been corrected, a maintenance program should be established. A maintenance program replaces the nutrients which have been removed by the previous crop. Further use of a build-up program will lead to excess nutrients which may increase the potential for water pollution.

Proper Timing of Application. The proper timing of fertilizer application can be important in increasing the efficient use of fertilizer. It is especially important for nitrogen fertilizers, which in nitrate form, is subject to leaching and denitrification.

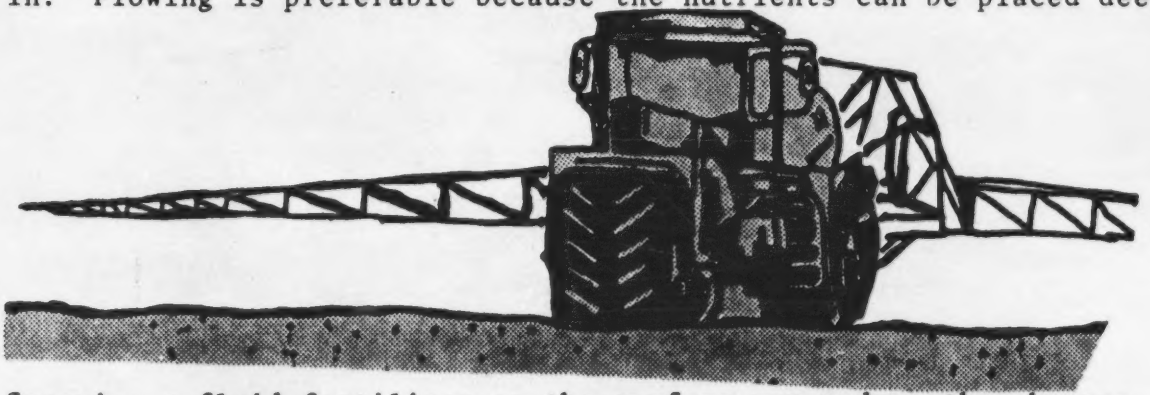
To receive the most efficient use of nitrogen, it should be applied near the time of maximum vegetative growth. Most crops grow the fastest several weeks after the plant emerges. This type of application of nitrogen is called sidedressing.

A fall application is recommended for non-nitrate and ammonium fertilization after the soil temperature drops below 50°F at a four-inch depth. Never apply fertilizers on saturated or frozen field. Fall application of nitrate forms of nitrogen are not recommended

Phosphorus and potassium can be applied to the crops when needed, either spring or fall. Because of the tendency to be immobile in the soil, an application of phosphorus and potassium may be enough to meet the needs of the crops to be grown in the next two to three year period in Illinois.

Method of Application. Band application of fertilizers has proven to be very effective in placing the nutrients to be utilized by crops. This method places the fertilizer at a depth greater than that of the seed. The fertilizer is away from the surface where it may be removed by erosion or runoff and in a location for contact with plant roots.

Broadcast application is when the fertilizer is applied uniformly over the surface of the field, usually before planting of the crop. It is recommended on high fertility soils if plowed or disked in. Plowing is preferable because the nutrients can be placed deeper.



Spraying a fluid fertilizer on the surface may reduce the chances of nutrient loss through runoff. Liquids or microcrystal suspensions may come in contact with soil particles sooner than granules which must dissolve over a period of time.

Row application is the placement of fertilizer at the side of the seed. This method of application is advised for areas which must be planted early in cool, wet soils.

Top dressed applications refer to applications of nitrogen on small grain crop after growth has begun.

Pop-up fertilizer application places the nutrients in direct contact with the seed. This method of application will not make the crop emerge sooner but may increase growth during the first weeks.

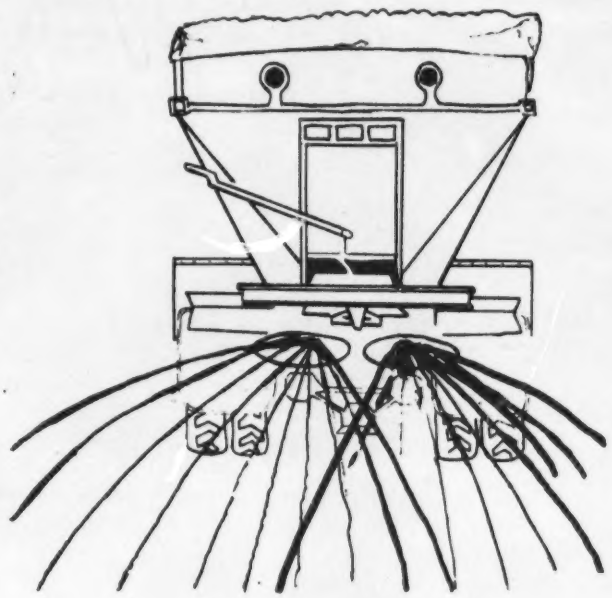
When applying fertilizers, animal manure, or sewage sludge, by any method, precautions must be taken to avoid direct application to in field waterways.

Special attention should be made to the timing and method of application of fertilizers. Use of the most efficient method and time of application for particular environmental conditions, soils and crops will result in higher yields and reduced potential for water pollution.

Nitrification Inhibitors. In areas where conditions are favorable for leaching and denitrification of applied nitrogen fertilizers, nitrification inhibitors may be effective in controlling nitrogen loss. Nitrification inhibitors are materials which restrains the soil organisms that transform ammonia nitrogen to nitrite forms. Poorly drained soils and course-textured soils (sands) may benefit the most. Success of nitrification inhibitors depends on many factors including soil condition, type of soil, geographic location, rate of nitrogen application, and weather conditions. Research has shown nitrification inhibitors may be beneficial to reducing the potential movement of nitrates into water resources.

Lime. Lime is one of the most neglected soil additives. It is essential in maintaining a proper pH for efficient crop production. Four pounds of lime are required to neutralize the acidity resulting from one pound of nitrogen in ammonia or urea application. As much as nine pounds of lime are needed to neutralize the acidity resulting from one pound of nitrogen as ammonium sulfate.

Soil acidity affects nutrient efficiency and plant growth. Toxic levels of manganese and aluminum may be present in acid soils. Many plant nutrients become unavailable if pH drops below 5.0.

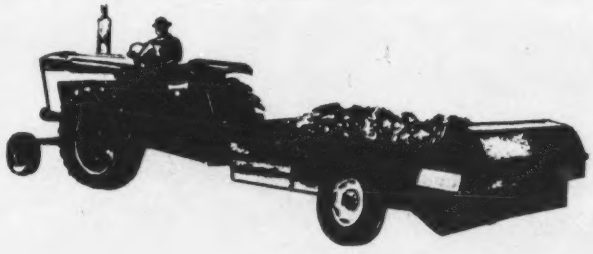


Lime can improve acid soils. A soil test is used as a guide for liming applications. For cropping systems with legumes, a pH goal of 6.5 should be established. A pH of at least 6.0 should be set for cash grain systems. Raising the pH above 6.5 for cash grain systems is not likely to enhance profitability of production.

At the 6.0 to 6.5 pH level, most of the essential nutrients increase in availability. The growth of symbiotic nitrogen-fixing bacteria is encouraged. Phosphorus compounds in the soil become more soluble and could reduce the amount of phosphorus needed.

Applying limestone according to need, as shown by soil test, will not immediately raise the pH to the desired level, but it will produce better crop yields. The price of limestone has remained favorable compared to other major crop production items. When a field is strongly or slightly acid, limestone will give a better economic investment than other crop production items.

Use of Animal Manures. Animal wastes, or manure, have been used as a source of plant nutrients for hundreds of years, Until the late 1930's, American farmers believed manures were the best form of fertilizer. By the mid-1940's, animal manures were being replaced by a low cost and plentiful supply of chemical fertilizers. Now that much of the livestock and poultry in the United States is being raised in confined lots producing an estimated 990 million tons of manure a year, a new look is being taken at animal manure as a source of plant nutrients.



Two practices are mainly used in disposing of animal wastes. The solid waste system is the collection of solid manure and bedding. This is then spread on fields when the weather, soil, and crop condition permits. The second system is a liquid waste system. It can either be a liquid pit which is a deep pit which is anaerobic, an oxidation ditch which collects manure in a slurry form and is mechanically stirred (aerobic), or a lagoon, a large

basin with mostly water. A lagoon can be stirred (aerobic) or not stirred (anerobic).

The nutrient content of animal manure varies due to animal, feed, bedding, and waste management system. It is recommended that manure to be used as fertilizer should be analyzed for N-P-K content. Research has indicated poultry waste with bedding has the highest percentage of available nitrogen, phosphorus, and potassium. For maximum conservation of the three primary nutrients, the liquid pit and oxidation ditch were found superior to the other systems.

Animal manures on fields and pastures may improve plant growth. Manures increase the organic matter in the soil resulting in slow release of primary and secondary plant nutrients and a decrease in soil density allowing movement of more air and water in the soil. The water holding capacity of the soil may also be improved reducing runoff.

Although the use of animal manures can be economically sound, it can have potential to pollute water resources. Runoff is a serious problem when manures are applied to frozen ground. Runoff from this type of application can contain ten to twenty percent of the nitrogen and phosphorus in the manure. It is best to store manure until weather permits the plowing under of the applied manure. If the manure is in a slurry form, it can be injected into the soil eliminating most of the potential for runoff of nutrients.

sludges can be an environmental hazard on soils of a fine clay, course sand, or gravel composition. The ideal soil for the use of sewage sludge is a well drained medium textured soil with a pH between 6.5 and 7.2, high in organic matter, level, and deep. The surface should support dense growth, so surface and subsoil roots are thick to hold the nutrients.

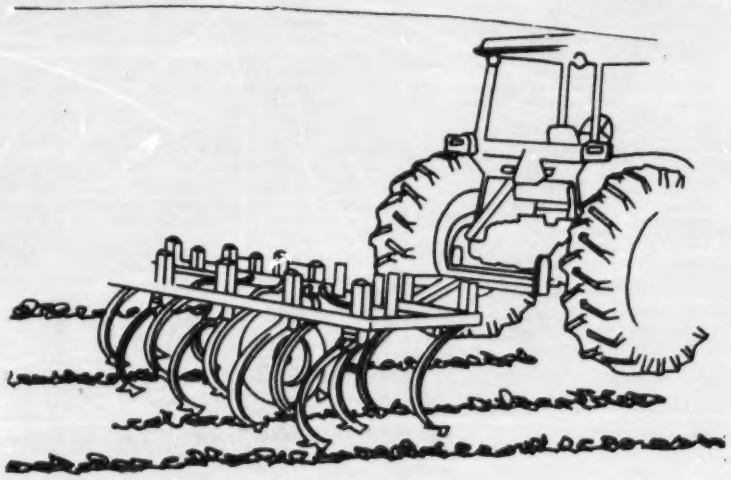
Sewage sludge can be a greater environmental hazard when toxic quantities of heavy metal cations contained in the sludge are adsorbed by the soil particles. Once adsorbed, these cations cannot be leached; the only way to remove toxic heavy metal cations is to remove the entire soil in which they are concentrated.

When using animal manures and sewage sludge, the potential environmental hazards must be acknowledged. The best solutions to these potential hazards is to prevent them from happening. If animal manures and sewage sludges are to be used with chemical fertilizers, the rates of application should be determined by the total amount of plant nutrients available from all of the sources. Agronomic rates should not be exceeded.

Use of Green Manure and Legume Crops. A green manure crop is grown and incorporated in the soil to add organic matter and improve crop yields. Like animal manure, the growing of green manures and legumes decreased in the mid-1940's when the chemical fertilizer industry grew.

Leguem crops are commonly used as green manures, but not all green manures are legumes. Legumes are the host plants for bacteria

which convert atmospheric nitrogen into available nitrogen; this process is call symbiotic nitrogen fixation. Often used for crop rotations, legumes can produce a valuable crop such as soybeans, and add nitrogen to the soil for the next crop. The roots of the harvested legume crop can be plowed under to add organic matter to the soil.



Green manures and legume crops are frequently used as winter cover crops. In this way, erosion is controlled. In the spring, the benefits of plowed-under green manure to the soil include increased tilth and slow release of nutrients.

Green manures and legume crops help reduce the potential loss of nutrients by crop rotation, erosion control, and reducing the requirements of added chemical fertilizers. At the same time, green manures and legumes are only a minimal hazard to water quality.

Summary

Using safe, sound soil and fertilizer management practices can aid in the prevention of possible contamination of Illinois water resources. When working with fertilizers, precautions must be taken to prevent accidental injuries to humans and the environ-

ment. Soil conservation practices will help reduce the amount of soil erosion and runoff avoiding possible movement of nutrients into water systems.

A soil test is the basis of sound fertilizer management practice. From soil test information, a fertility build-up or management program can be established. These programs determine the amount, form, time of application and type of fertilizer application which will produce the best crop production results.

The use of additives such as nitrification inhibitors, lime, and alternate nutrient sources such as animal manures, sewage sludge, green manures, and legume crops, can reduce the amount of chemical fertilizers needed. As the amount of fertilizers applied is decreased, the potential for fertilizer related pollution of lake, ponds, streams, wells, and rivers is also reduced.

The use of fertilizers will continue to be an important part of improving crop yields. The increased use of fertilizers in Illinois creates a potential for water contamination. The major concern is with the movement of nitrogen and phosphorus into water sources.

Fertilizers are available in gaseous, liquid, or solid forms. Although fertilizers are beneficial to crop production, they can be harmful to the environment if carried away into water sources.

When fertilizers enter water sources, they can become toxic to human, animal, fish, and plant life. Knowing how fertilizers can

contaminate water and how to use fertilizers safely can eliminate some of the problems connected with fertilizer pollution of water.

The overuse of fertilizers can lead to economic losses when excess nutrients are applied to soils.

Nutrient loss and pollution of Illinois water resources can be minimized by utilizing sound fertilizer management practices. Efficient use of fertilizer is economically and environmentally beneficial.

KEY QUESTIONS

CHAPTER 5

1. Use of soil _____ practices, such as minimum tillage, no-till (zero-tillage), cover cropping, contouring, and terraces have proven to be helpful in reducing movement of nutrients.
2. The most efficient use of _____ is also the most economical.
3. The most important guide to proper use of fertilizer is a regular _____ _____ .
4. A _____ program establishes a procedure to increase soil fertility to the desired nutrient levels.
5. A _____ program replaces the nutrients which have been removed by the crop.
6. The proper timing of fertilizer _____ can be important in increasing the efficient use of fertilizer.
7. Special attention should be made to the timing and _____ of application.
8. Research has shown nitrification _____ may be beneficial to reducing the potential movement of nitrates into water resources.
9. _____ is essential in maintaining a proper pH for efficient crop production.
10. Animal _____ on fields and pastures can improve growth.

11. If animal manures and sewage sludges are to be used with chemical fertilizers, the rates of application should be determined by the total amount of plant _____ available from all of the sources.

12. A green manure crop is grown and incorporated into the soil to add _____ _____ and improve crop yields.

13. Legumes are host plants for _____ which converts atmospheric _____ into available nitrogen.

Answers are listed in the back of the booklet under Chapter 5.

KEY QUESTIONS ANSWER SHEET

CHAPTER 1

1. fertilizers
2. environment
3. water
4. U.S. EPA (Federal)

CHAPTER 2

1. elements
2. sixteen
3. primary
4. smaller
5. fertility
6. application
7. water
8. water
9. biological

CHAPTER 3

1. products
2. water
3. adsorption
4. conservation
5. soil
6. nitrogen
7. overabundance
8. soluble
9. oxygen
10. limit
11. nitrogen
12. economic
13. eutrophication
14. dissolved
15. problems

CHAPTER 4

1. fertilizers
2. dangerous
3. pollution
4. anhydrous
5. water
6. suitable
7. applicator
8. protective
9. water
10. water
11. drink
12. inhaled
13. destroyed
14. poured
15. delayed

CHAPTER 5

1. conservation
2. fertilizers
3. soil test
4. build up
5. maintenance
6. application
7. method
8. inhibitors
9. lime
10. manures
11. nutrients
12. organic matter
13. bacteria/nitrogen

GLOSSARY OF TERMS

Absorption - the ability to take gas, liquid, or dissolved fertilizers inside of a particle.

Adsorption - the ability to collect gas, liquid, or dissolved fertilizers to the outside of a particle.

Anhydrous ammonia - (NH_3) a form of nitrogen fertilizer, usually a gas when applied but stored as a liquid.

Band application - fertilizer is placed at a depth greater than the seed.

Broadcast application - fertilizer is applied uniformly over surface of a field.

Build-up program - a program to increase soil fertility to desired levels.

Caustic - the burning, eating away, or destroying of tissue by chemical action.

Core samples - a cylindrical section of soil layer obtained with a hollow drill.

Contouring - plowing or terracing to keep a level line at right angles to the direction of the slope, usually results in a curving row.

Cover Cropping - the practice of sowing a crop to cover field during the winter months to reduce runoff and soil erosion.

Deficiency - a shortage of some element.

Denitrification - the changing of nitrate (NO_3^-) to atmospheric nitrogen (N_2) by soil microorganisms.

Dermal injury - injury to the skin.

Drainage lysimeters - columns of soil surrounded by water tight cylinders.

Eutrophication - the increase of plant nutrients in water resulting in overabundance of plant growth.

Green manure- plant crop that is grown for incorporation into the soil to add organic matter.

Homogeneous - composed of similar elements

Inhalation injury - injury resulting from the breathing in of toxic vapors.

Lagoon - a large basin with water for storage of solid and liquid animal wastes.

Leaching - the removal of dissolved minerals from the soil by water which is moving through the soil.

Legumes - plants whose roots are hosts for nitrogen fixating bacteria.

Liquid pit - a deep pit to hold liquid animal wastes without mixing with oxygen.

Liquid waste system - animal wastes are stored in a slurry form in this type of system.

Methemoglobinemia - an illness in which nitrites interact with components in the blood to interfere with the movement of oxygen in the body.

Micronutrients - seven nutrients which are important to plant growth, but are usually needed in smaller amounts.

Mucous membranes - the lining of the respiratory tract (found in the nose).

Nitrates - (NO_3^-) the nitrogen form which is available to plants for growth.

Nitrification - the biological oxidation of ammonia to nitrate.

Nitrification inhibitors - materials which restrain the soil organisms that break down nitrogen to nitrate forms.

Nitrite (NO_2^-) - the nitrogen form in the breakdown cycle before nitrates; this form can be toxic to humans and animals.

Nutrients - nine of the sixteen basic elements needed for plant growth. Also used to describe all elements needed for plant growth.

Oral injury - injury resulting from drinking or swallowing toxic materials.

Organic matter - soil compounds from the decomposition of plants and animals by microbil activity.

Oxidation ditch - an outside ditch which allows oxygen to reach the manure slurry with the aid of mechanical device.

pH - a notation to designate the degree of acidity or alkalinity. The concentration of hydrogen ions in a solution. pH below 7.0 - acidic; pH 7.0 - neutral; pH above 7.0 - alkaline.

Phosphates - the available form of elemental phosphorus.

Pop up applications - nutrients are placed in direct contact with the seed.

ppm - parts per million.

Primary nutrients - Nitrogen (N), Phosphorus (P), and Potassium (K) are required in large amounts for plant growth.

Row application - the placement of fertilizer at the side of the growing seed.

Runoff - refers to the loss of water by surface flow, and occurs when the water cannot infiltrate the soil.

Secondary nutrients - Calcium (Ca), Magnesium (Mg), and Sulfur (S) are needed for plant growth but not usually added in large quantities.

Side dress applications - refers to application of nitrogen fertilizers after the crop has begun to grow.

Soil cation exchange capacity - the amount of exchangeable positive charged ions that can be adsorbed by a mass of soil (expressed as milliequivalents per 100 grams of oven-dry soil).

Solid waste system - the storing of manure and bedding in a non-liquid form.

Soil erosion - the movement of soil particles out of a field by wind or water.

Soil fertility - the quality of a soil to provide the needed nutrients in the needed amounts for plant growth.

Sybiotic nitrogen fixation - the converting of atmospheric nitrogen into an available form by legume bacteria.

Tile drains - short lengths of pipe laid under the soil to collect and carry excess water from the field.

Tillage - the plowing of the land.

Top dressed applications - the applications of nitrogen after growth has begun, usually applied to small grain crops.

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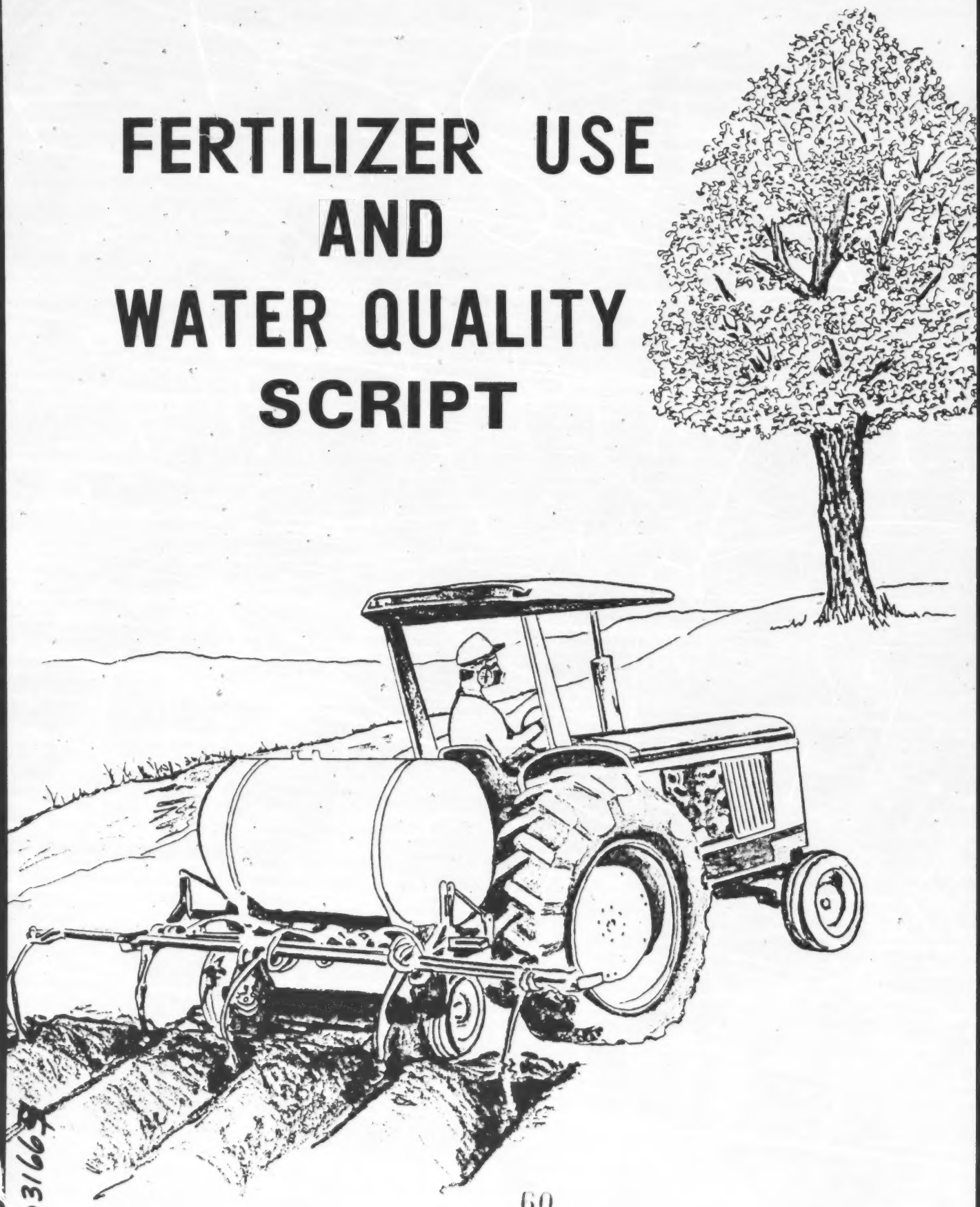
FERTILIZER USE AND WATER QUALITY SCRIPT



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FERTILIZER USE & WATER QUALITY

SCRIPT

Prepared by

Fred Reneau - Assistant Professor

Janise Richards - Graduate Assistant

Department of Agricultural Education and Mechanization
Southern Illinois University - Carbondale

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SCRIPT

Slide No.

1. Fertilizer Use and Water Quality.

2. Fertilizers have been used to improve crop yields for centuries. The benefits of fertilizer make it an important part of farming practices.

3. With the help of fertilizers, American farmers have exceeded the food and fiber needs of the United States. This surplus has helped the United States become one of the leading agricultural exporters in the world.

4. Fertilizers benefit agricultural production but may cause adverse conditions in the environment due to misuse and/or overuse.

5. The increase of fertilizer use in Illinois has caused concern about the potential movement of nitrogen and phosphorus into water sources. The use of sound fertilizer management practices is essential for maintaining water quality.

6. To control environmental pollution, the federal government passed the Federal Water Pollution Control Act Amendment of 1972. This gave the United States Environmental Protection Agency a mandate to restore and maintain the quality of the nation's water resources.

7. For maximum yields, plants must have optimum temperatures, available soil, air, and water, ample light, and the essential elements of nutrients available when needed. Fertilizers are used to supply essential elements to the plant.

8. Most plants require sixteen basic elements, with the help of light and heat to manufacture food. Nine of the sixteen basic elements are called macronutrients. Hydrogen and oxygen are usually available to plants and are not important in fertilizer consideration.

9. Nitrogen, phosphorus, and potassium are called primary nutrients. Primary nutrients are needed by the plants in substantial amounts.

10. Magnesium, calcium, and sulfur are known as secondary nutrients. The use of secondary nutrients depends on the plant species, soil conditions, and environment.

11. Seven of the sixteen basic nutrients are called micronutrients. The term micronutrients means the nutrients are needed by plants in small amounts. Zinc, iron, copper, manganese, boron, molybdenum, and chlorine are classified as micronutrients.

12. When considering fertilizer applications, farmers must know the fertility of the soil. Soil fertility is the quality that allows the soil to provide the essential elements for growth of plants.

13. Soil samples should be taken at least every four years in the late summer or fall. A minimum of five soil samples for every three or four acres should be taken and combined to make one composite sample of the area.

14. Nitrogen fertilizers have helped boost agricultural production. Commercial nitrogen fertilizers can be bought in many forms, gaseous, liquid, or solid. Each of these nitrogen sources are beneficial to crop production, but can be harmful to the environment if carried away by wind, rain, or soil erosion.

15. Commercial phosphorus fertilizers are developed from rock phosphate, a mined mineral. In its inorganic form, even very small amounts of phosphorus can increase biological activity in streams, lakes, or other water sources.

16. Commercial potassium fertilizers are processed from mineral ore. Potassium usually is not a source of water pollution.

17. Chemical fertilizers which contain more than one macronutrient are called mixed or complete fertilizers. On the bag, tank, or tag, the analysis is given for the nitrogen content, the phosphorus content, and the potassium content.

18. Fertilizers become a hazard to the environment when they move off of cropland into water resources. When fertilizers enter water systems, it may become toxic to human, animal, fish, and plant life.

19. One way nutrients can enter water sources is through leaching. Nutrient leaching is the removal of dissolved minerals from the soils by water that is percolating through the soil.

20. Qualities that cause fertilizers to stick to small soil particles are known as adsorption. Adsorption is necessary for fertilizers to do their jobs effectively. Adsorption helps avoid fertilizer pollution of water resources, except when soil erosion occurs, moving adsorbed nutrients out of the field with eroded soil particles.

21. Possible damage to streams, rivers, lakes, and other water systems, resulting from the adsorbed nutrients which may dissolve into the water, can be reduced by use of sound soil conservation practices.

22. Runoff refers to loss of water by surface flow through stream channels. It occurs when the rate of water application to the soil exceeds the rate of water infiltration into the soil.

23. The highest potential for water pollution from runoff water exists when the solubility of a fertilizer is high, such as with recent surface application of fertilizer or when the soil pH, cation exchange capacity, moisture content, mineral clay content, and organic matter are such that fertilizers are not easily adsorbed.

24. As a precaution to prevent water pollution from runoff, surface application of fertilizers should <u>NOT</u> be made when rain is forecasted.

25. Nitrogen fertilizer use has increased in Illinois. This increase may lead to an overabundance of nitrogen in the environment.

26. When nitrogen fertilizer is added to the soil, it is primarily in the ammonium form. If the ammonium is not taken in by plants, it enters a nitrification process.

27. In the first stage of the nitrification process, bacteria change the ammonium form into a nitrite form of nitrogen. Then, the nitrite form is quickly changed by further soil bacteria activity into the nitrate form. This nitrate form, if not adsorbed by plants, may leach because nitrates are not adsorbed by clay particles and are very water soluble.

28. The U. S. Public Health Service established the Drinking Water Standards of 1962 to set a limit for nitrates in water systems for human consumption. The maximum limit was fixed at ten milligrams nitrogen per liter of water or 45 ppm nitrate.

29. When water contaminated by nitrates and nitrites is consumed by humans or animals, the nitrates and nitrites interact with components in the blood to interfere with oxygen transport in the body. If not properly treated, it may be fatal.

30. Young children are especially susceptible to nitrate and nitrite poisoning.

31. Fish, animal, and plant life are also sensitive to nitrogen forms in water systems. As little as one to two ppm of dissolved ammonia can be fatal to some species of fish.

32. The difficulty of pinpointing the source of nitrates in water systems comes partly from the nitrification process. It is complicated by industrial pollution from sources such as factories, sewage disposal plants, and automobiles, that cannot always be easily identified. Once nitrogen has started through this cycle, the source cannot always be determined.

33. Since the early 1960's, the amount of phosphorus fertilizer used by Illinois farmers has steadily increased. Because phosphorus is immobile in the soil, it can build up to a point where the phosphorus content is unnecessarily high for best economic yields.

34. Once the soil has reached a specified nutrient level, the amount of phosphate fertilizer needed is equal to the amount removed by the harvested crop. This practice is economical and decreases the chance of phosphate pollution of water sources.

35. Most phosphorus compounds are highly attracted to clay particles and have limited water solubility. This helps to prevent phosphates from leaching into water systems, but soil erosion and runoff water can move phosphates from fields into water resources.

36. When phosphates and nitrates enter water resources, the water may become enriched by the nutrients resulting in vigorous growth of algae and aquatic plants. This condition is called eutrophication.

37. The concentrations of phosphorus are most important in bringing about accelerated eutrophication. Accelerated eutrophication begins when phosphorus concentrations surpass about .015 milligrams per liter of water.

38. In the first stage of eutrophication, there is rapid growth of algae and aquatic plants. When this plant material dies, the biological activity involved in its decay uses up the dissolved oxygen supply from the water. Without the dissolved oxygen in the water, fish cannot live.

39. Safe use of fertilizers is essential to the health of the applicator and the environment. Fertilizers are usually not thought of as dangerous chemicals and frequently are not handled cautiously.

40. When loading and unloading bulk fertilizers, protective gloves and goggles should be worn to prevent dusts, vapors, or liquid from entering eyes or small cuts in the skin.

41. Dry and liquid fertilizers should be stored where there is no exposure to the weather. Avoid storing fertilizers where accidental loss of nutrients would contaminate surface water or wells.

42. Anhydrous ammonia is the most common form of nitrogen fertilizer used by Illinois farmers. The applicator should know the characteristics of anhydrous ammonia, the dangers and the precautions to be taken.

43. Anhydrous ammonia is a colorless, lighter than air gas with a pungent, irritating odor under atmospheric temperature and pressure. It can be compressed into a liquid form for easier handling.

44. Because anhydrous ammonia has an extremely low boiling point, -28 degrees Farenheit, it causes skin tissue to freeze immediately on contact.

45. Ammonia is strongly attracted to moisture, which may result in injury to the eyes, skin, mucous membranes and respiratory tract. Flushing with water immediately is the most effective treatment of areas that have been in contact with anhydrous ammonia.

46. The applicator should only use equipment suitable for anhydrous ammonia and be certain it is properly installed.

47. The applicator should establish a sound program for inspection, repair, and maintenance of equipment. When in use, a daily check should be made of the ammonia tank, valves, fittings, pipes, hoses, transfer equipment, transport and nurse tanks for leaks, deterioration, or damage.

48. The applicator should provide and maintain standard protective equipment. Rubber gloves and tight fitting goggles must be worn when working with anhydrous ammonia.

49. Clothing constructed of closely woven cotton and boots are recommended attire for handling anhydrous ammonia. Gas masks with ammonia-type canisters are also recommended.

50. A supply of fresh water of five gallons or more must be on both the nurse tank and tractor. A small pocket squeeze bottle full of water should be carried at all times for immediate access in case of eye injury.

51. Anhydrous ammonia can cause blindness if treatment is delayed. As long as it is in contact, tissues will be destroyed. A small pocket plastic squeeze bottle is invaluable to give eyes immediate attention.

52. A larger supply of water should be used to wash eyes effectively. Eyes must be forced open and held to insure contact of water with all tissues for at least 15 minutes. A physician should be contacted.

53. In unusual circumstances, liquid anhydrous ammonia may be swallowed. If this happens, call a physician immediately. A conscious, able person should drink large amounts of water to dilute the chemical.

54. If anhydrous ammonia vapors are inhaled, the exposed person should be moved at once to an uncontaminated area. A severe exposure requires oxygen to be administered by authorized personnel, and a physician should be called.

55. Water should be poured over the injured area immediately. Clothing contaminated with anhydrous ammonia should be removed under pouring water if frozen to the skin.

56. REMEMBER, accidents involving anhydrous ammonia can happen from equipment failure and/or disregard of proper operating instructions. In case of an emergency, water is the best treatment to stop anhydrous ammonia injury.

57. Connection between the use of fertilizer and concentrations of nutrients in water systems has been recognized. Each person who uses fertilizers should do so in a safe and sound manner to reduce potential contamination of Illinois water resources.

58. Most nutrient movement from the field is from leaching, erosion, and runoff. No-till or zero tillage, a soil conservation practice in which crop residue is left on a field, has been found effective in controlling both soil erosion and runoff.

59. The practice of sowing a cover crop during the winter months reduces runoff and soil erosion. Contouring is another soil conservation practice that reduces nutrient loss by breaking up long slopes where soil erosion is common.

60. Nutrient loss, economic loss, and pollution of water resources can be minimized by the use of sound fertilizer management practices.

61. A build-up program establishes a procedure to increase soil fertility to desired nutrient levels. This program usually consists of a soil test, establishment of amount of fertilizer needed, decisions on forms of fertilizer to use and what analysis would be best suited, an estimate of cost, and a determination of where and when to apply the fertilizers.

62. The most important guide to proper use of fertilizer is a routine soil test. Soil samples should be tested for soil pH, available phosphorus, and potassium.

63. Proper timing of fertilizer application can be important for efficient use of fertilizer. Fall application of non-nitrate and ammonium fertilizer is recommended, but not for nitrate forms. Phosphorus and potassium can be applied to the crops when needed.

64. Band application places the fertilizer at a greater depth than the seed. It is an effective way to place fertilizer away from the surface where it may be removed by erosion or runoff and in a location for contact with plant roots.

65. Broadcast application is when fertilizer is applied uniformly over the surface of the field. It is recommended that the nutrients be plowed or disked into the soil to prevent runoff of nutrients if soil erosion is not a concern.

66. Spraying a fluid fertilizer on the surface may reduce the chances of nutrient loss from runoff.

67. In conditions that are favorable for leaching and denitrification of applied nitrogen fertilizers, nitrification inhibitors may be effective in controlling nitrogen loss. Their success depends on many environmental factors, but their use may be beneficial in reducing the potential movement of nitrates into water resources.

68. Lime is essential in maintaining a proper pH for effective crop production.

69. Lime can improve soil acidity which may have negative effects on plant growth. At the 6.0 to 6.5 pH level, most of the essential nutrients become more available, and growth of symbiotic nitrogen-fixing bacteria is encouraged.

70. Animal wastes, or manure have been used as a source of plant nutrients for hundreds of years. The nutrient content of animal manure varies due to animal, feed, bedding, and waste management systems; therefore, manure to be used should be analyzed for nutrient content.

71. Although the use of animal manures can be economically sound, it may pollute water resources when applied to frozen ground and run-off occurs.

72. Research on sewage sludge indicates it has about the same fertilizer value as animal manure. Sewage sludge must be used with great care because of the toxic qualities of the heavy metal cations which it contains. As with animal manure, sewage sludge may be a potential source of water pollution from runoff.

73. A green manure crop is grown and incorporated into the soil to add organic matter and improve crop yields. Legume crops are host plants for bacteria which convert atmospheric nitrogen into available nitrogen and are commonly used as green manures.

74. Green manures and legume crops are frequently used as winter cover crops to control erosion. In the spring, the benefits of plowed under green manure to the soil include increased tilth, slow release of nutrients, and a reduction in the need of commercial fertilizers. At the same time, they are only a minimal hazard to water quality.

75. The use of fertilizers will continue to be an important part of improving crop yields. Although fertilizers are beneficial to crop production, they can be harmful to the environment if carried away into water resources.

76. Utilizing sound fertilizer management practices will help agriculture to prosper and reduce fertilizer pollution potential in Illinois water resources.

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78. Southern Illinois University, Department of Agricultural Education and Mechanization; funded by:

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